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INTERNATIONAL SAFEGUARDS: EXPERIENCE AND PROSPECTS

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The international safeguards system of inspection and independent verification is essentially unique in the application of the rule-of-law in relations among sovereign nations. International Atomic Energy Agency (IAEA) safeguards have been applied, in one form or another, for nearly twenty years, and have amassed a very significant record of progress and achievements. Today over 95% of the nuclear material and facilities, outside of nuclear weapon states, are under IAEA safeguards. Although the accomplishments and expansion of safeguards to date have been impressive, one must not underestimate the challenge and the realities that lie ahead as many countries of the world move toward expanded nuclear power (both LWRs and fast breeder reactors) and supporting fuel-cycle facilities.

A spate of safeguards criticism, inquiries, studies, etc., inevitably follows in the wake of a major safeguards-related event such as the bombing of the Tamuz-1 reactor in June 1981. It has become abundantly clear that there is little or no prospect of any major changes in the existing international safeguards system of agreements or in their institutional framework. Thus the present system of non-proliferation agreements (mainly NPT) implemented by IAEA safeguards is what we have in place, and indeed is all we're likely to have in the foreseeable future. Therefore the clear task before the world nuclear community is to maintain and strengthen the existing system of non-proliferation undertakings and to increase the effectiveness of nuclear safeguards on both the international and the national (State) level.

It is equally clear that the effectiveness of the overall international safeguards regime rests largely on the effectiveness of the State systems, and in turn the individual facility systems, whose performance the international system must independently verify. A fully effective safeguards and security system at a nuclear facility depends on a combination of three basic components, (1) materials measurement and accounting, (2) materials control, including (as appropriate) process monitoring, and (3) physical protection. Of these, only the materials measurement and accounting component offers the possibility of determining the amount and location of the material in a plant at any given time. Such capability for determining nuclear material inventory with adequate sensitivity and timeliness would provide an overall quantitative check on the combined effectiveness of all other safeguards and security measures at a facility. This unique role of measurement and accounting has led over the years to increasingly stringent requirements being placed on measurement capabilities for all types of nuclear materials, and this in turn has led to the development of a new measurement technology -- now commonly known as nondestructive assay (NDA).

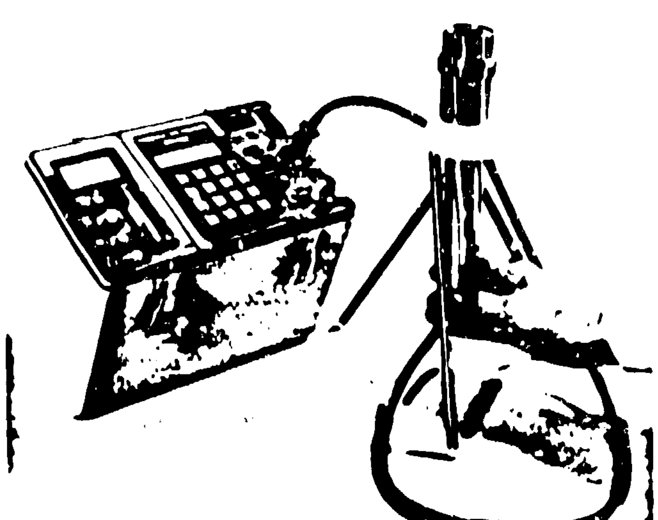
The new NDA techniques complement, and sometimes supplant, the traditional destructive assay methods of analytical chemistry. NDA techniques fall into two major categories, active and passive. Active assay involves irradiation with neutrons or photons to induce fissions in the sample. The resulting neutron or gamma-ray "signatures" are interpreted to determine quantitatively the amount of fissionable material present. Passive assay uses naturally occurring gamma-ray and/or neutron radiations as direct signatures of fissionable materials.

NDA methods are being developed and applied to various aspects of inspection, assay, and accountability of fissionable materials found in the fuel cycle. This includes feed and product as well as a wide variety of fresh and spent reactor fuels, residues, and wastes generated by the nuclear industry. NDA instruments range in size and complexity from small portable units (e.g. as small as a carry-on suitcase) for use by IAEA inspectors in on-site verification of nuclear materials, to large in-situ NDA systems designed for routine in-plant use (e.g. by plant operators, subject to independent authentication by IAEA or State System inspectors). When and as appropriate, measurement results can be formatted for direct input to a computerized "near-real time" material accountability and control system, which can serve not only the needs of safeguards and materials management, but also of plant process and quality control, criticality safety, radiological protection, etc.

One example of a portable instrument designed specifically for safeguards inspector use is the Mini-MCA (multichannel analyzer) unit recently delivered to the IAEA (see Figure 1). This unit is illustrative of an emerging new generation of NDA instruments with built-in "intelligence" which can greatly aid the inspector during specific inspection and verification measurements.[1] The new intelligent instruments are designed to prompt the user through the basic instrument functions, to provide automation of specific inspection measurements, and to perform all necessary calculations internally. They should be able to log both raw and reduced data. Calibration should be built in or calibration procedures should be automated. As appropriate, the instrument should be able to control, or be controlled by, or to communicate with, another instrument or information system. Insofar as possible the intelligent instruments should ha their own built-in diagnostics.

A special hardware-software interface design in the Mini-MCA has made possible the development of a powerful inspector-instrument interface, which allows the inspector and the instrument to carry on a dialogue. This dialogue is essential in the automation of specific inspector measurements. The first step in automating a measurement is to specify the measurement procedure in detail. The programmer then designs the logic to implement this procedure as a special analyzer function. In implementing the logic, routines already resident in the mini-MCA are called to display prompting messages, to execute basic instrument fuctions, and to perform the specific calculations for the measurement.

Figure 1
The Los Alamos Portable Multichannel Analyzer, along with the NaI detector in the configuration appropriate for enrichment measurements. The analyzer is battery powered and contains sufficient measurement and analysis software to direct a complete enrichment measurement.



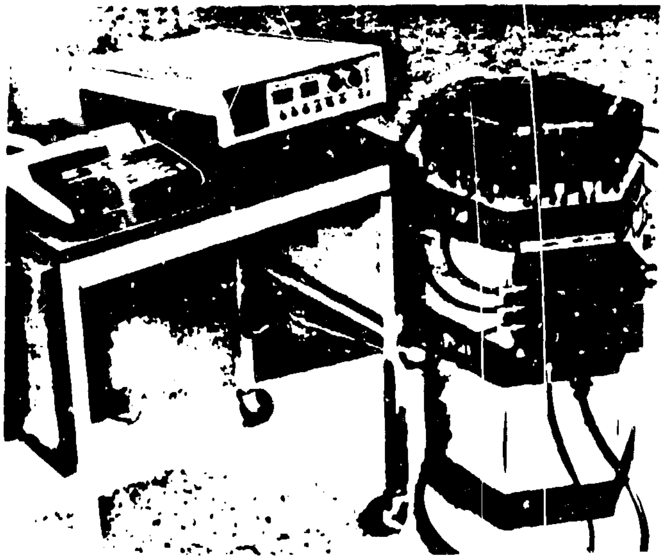
The Mini-MCA has a wide range of applications. Already implemented is a U-235 enrichment measurement using a NaI gamma-ray detector. All results, including error analysis, are calculated by the instrument. Applications presently being implemented include: UF_6 measurements, material-test-reactor fuel measurements, and verification of in-plant instrumentation. The Mini-MCA also lends itself to plutonium isotopics and to combination neutron and gamma-ray measurements for total plutonium assay (both elemental and isotopic). The Mini-MCA has also been used for making in-plant measurements of nuclear material "holdup" and for measurements on spent reactor fuel.

Another notable example of portable instrumentation for IAEA inspectors is the family of neutron coincidence counter systems, all based on a common "shift register" standard electronics unit that has been developed to measure coincident neutrons accurately over a wide dynamic range of counting rates.[2] This important family of instruments features not only common shift-register logic but also a common, standard procedure for data acquisition and interpretation, with only different detector heads being required to measure many different types of uranium and plutonium-bearing nuclear materials. Three different units in this growing family of neutron coincidence counter systems are pictured and briefly described in Figures 2-5.

The High Level Neutron Coincidence Counter (HLNC), shown in Figure 2, was originally developed for the verification of bulk samples of PuO_2 in the kilogram mass range. Because of the successful implementation of this equipment for plutonium, the IAEA wanted to apply similar instrumentation for the verification of HEU (highly enriched uranium) and LWR (light water reactor) fuel. This led to the development of the Active Well coincidence Counter[3] (see Figure 3) for various types of uranium fuel and the active neutron Coincidence Collar[4] (see Figures 4 and 5) for LWR unirradiated fuel assemblies. More recently, the neutron coincidence counting approach has been applied to LMFBR (liquid metal fast breeder reactor) fuel subassemblies.

Significant progress has been made by the IAEA in the verification of spent-fuel assemblies. The Javelin night-viewing device, shown in Figure 6, makes it possible to observe the intense Cerenkov radiation from spent-fuel assemblies in their underwater storage locations. For a more thorough inspection, the Agency can use the so-called "square ring" detector (see Figure 7) to measure the gross gamma-ray and neutron emissions from the spent-fuel

Figure 2
The High-Level Neutron Coincidence Counter (HLNCC) and its associated coincidence electronics. Normally operated in the passive mode with Pu samples, this counter can be equipped with neutron sources in the endplugs and used to assay uranium samples in the active mode.



assemblies. The Agency also has considerable experience with the use of high-resolution gamma-ray and neutron emissions from the spent-fuel assemblies.

The instruments in Figures 1-7 all exemplify an important trend in NDA in- ion development, namely toward n and standardization of ocedures for safeguards in- ther IAEA or State System in: the resulting intelligent and mutual patible instrumentation offers many advantages in inspector training, equipment acceptance, and routine in-the-field measurements, not to mention significantly reduced equipment maintenance and logistics problems. Major emphasis in the years just ahead will be on the practical implementation and routine field use of these and other measurement instruments, methods, and techniques that, together with containment and surveillance equipment and techniques, form the technical basis for the IAEA's safeguards inspection and verification activities worldwide.

Certainly good progress has been made and is continuing in the important area of safeguards technology development and implementation. However, the effectiveness of the international safeguards regime depends not only on technology but also on less tangible "human factors" that are extremely difficult to characterize, but certainly involve such basics as political/economic consensus, cooperation, and some degree of mutual trust and confidence among people and nations. This cooperation begins as early as the negotiation of a Safeguards Agreement between the IAEA and the State, followed by negotiation of subsidiary arrangements and later by the gathering of appropriate design information and working out of detailed facility attachments (i.e. specific inspection/verification procedures mutually agreed to by the IAEA and the State). Even after the State Safeguards System is fully implemented, there must be a continuing dialogue of questions, ideas, and experience e.g., in seeking reasonable interpretation of rules and limits in special cases or new situations, in keeping up with updated technology and procedures, new reporting requirements, forms, etc.

All of this need for knowledge, mutual understanding, and cooperation on the part of both the inspector and "inspected" clearly underscores the importance of training and technology transfer -- at the international, the State, and the facility

Figure 3
The Active Well Coincidence Counter (AWCC), along with its associated coincidence electronics. Neutron sources are mounted in the end plugs, and the counter assays uranium samples by counting coincidence neutrons from induced fissions in the U-235 present.

Figure 4
Neutron Coincidence Collar in measurement position around a PWR fuel assembly mockup.

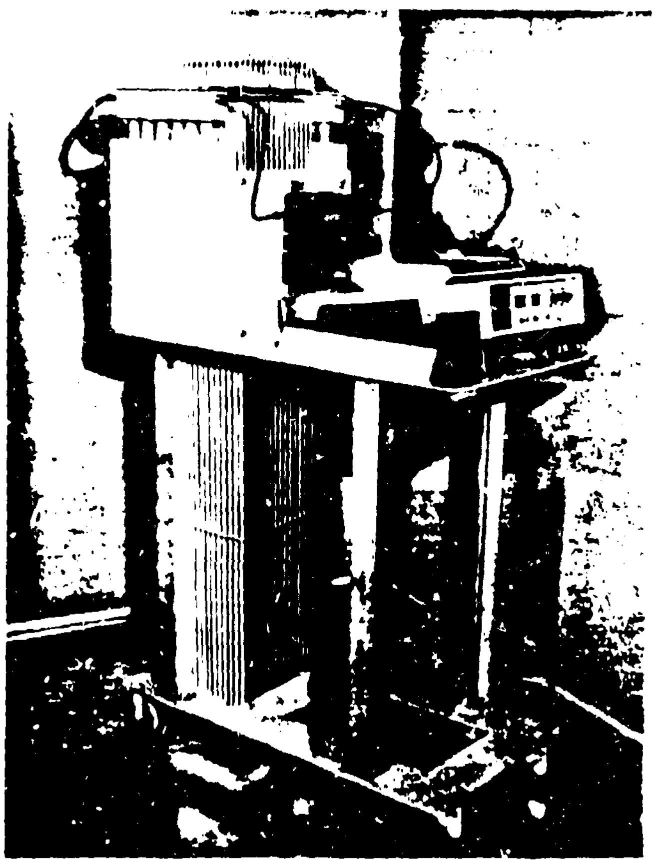
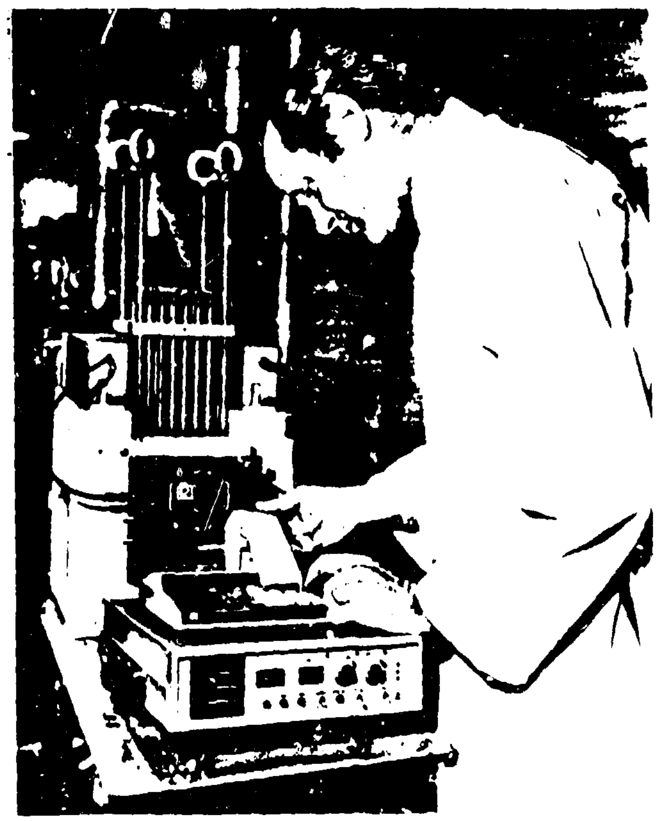


Figure 5
Howard Menlove, developer of the coincidence collar, checks the assay for a fuel assembly mockup of a boiling-water reactor. Neutron-assay instruments like this one are now used by the International Atomic Energy Agency in the verification of nuclear material inventories at fuel fabrication plants.



levels. It is gratifying that the expanding series of safeguards training courses (both at IAEA headquarters and in Member States) are now beginning to contribute not only to the technical effectiveness and objectivity of safeguards but also are helping to build a spirit of cooperation, mutual trust and confidence, and a shared sense of common professional dedication among safeguards people from around the world. It is difficult to over-estimate the importance and long-term significance of this latter factor because, as in all human endeavors, the actual implementation of effective and workable safeguards must be carried out by people -- and moreover by qualified people with the requisite training, knowledge, and motivation.

With regard to the role of State safeguards systems and their interface with the Agency, an increasing number of IAEA Member States are beginning to look to the Agency (and major supplier nations) for training and assistance in establishing and/or upgrading their own national safeguards systems. In this emerging area of safeguards training and technology transfer, the coordinated efforts of the Agency and nuclear supplier nations are contributing positively to the effectiveness and acceptability of both State systems and IAEA international safeguards. In the future the IAEA, as the focal point of safeguards worldwide, may be able to serve a more active role in the introduction and transfer of modern safeguards technology and methods to Member States (both developing and advanced) wishing to establish or improve their State systems of safeguards. As already noted, the effectiveness of the overall international system depends in large measure on the effectiveness of the State Systems (and in turn the operators' systems) whose performance the international system must independently verify. In this connection it should be further noted that methods and technology to provide independent authentication of the facility operator's measurement systems are also being developed to help accomplish overall safeguards goals.

The basic thrust of this presentation can perhaps be most succinctly summarized as follows: for safeguards to work, the equipment must work and the people must work. (" Work " being here defined as

Figure 6
The night-viewing device that can be used to detect the Cerenkov radiation emitted by spent fuel stored in cooling ponds.

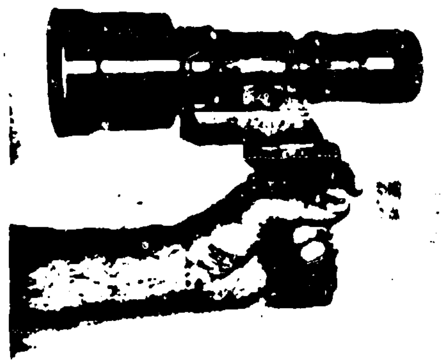
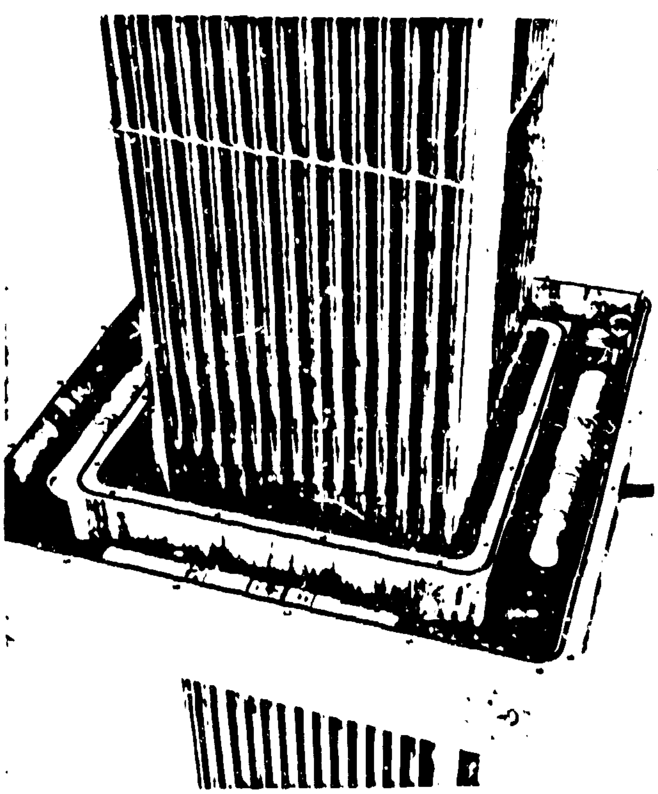


Figure 7
"Square Ring" detector containing an ion chamber and fission detectors (to detect gross gamma rays and neutrons respectively) placed around a 15 x 15 PWR fuel assembly.



"function effectively in the field.") Beyond the technical development of instruments, methods, and techniques for nuclear materials measurement, accountancy, surveillance, and control, this further requires effective equipment implementation, training, and technology transfer:

The overall goal of equipment implemenation is to close the gap between laboratory capability and the practical realities of in-plant and field operations.

The overall goal of training and technology transfer in the broadest sense, is to challenge, motivate, and bring out the best in the people (i.e. inspectors and "inspectees" from around the world) who together must make safeguards "work."

These twin goals offer a realistic basis for further significant progress in improving the effectiveness and efficiency of nuclear safeguards -- both domestic and international.

REFERENCES

1. J. K. Halbig and . F. Klosterbuer, "The Inspector-Instrument Interface in Portable NDA Instrumentation," IEEE Trans. Nucl. Sci., San Francisco, Ca., (October 21-23, 1981).

2. M. S. Krick and H. O. Menlove, "High-Level Neutron Coincidence Counter (HLNCC)," Los Alamos Scientific Laboratory report LA-779-M (ISPO-5') (June 1979).

3. H. O. Menlove, "Description and Operation Manual for the Active Well Coincidence Counter," Los Alamos Scientific Laboratory report LA-7823-M (1979).

4. H. O. Menlove, "Description and Performance Characteristics for the Neutron Coincidence Collar for the Verification of Reactor Fuel Assemblies," Los Alamos National Laboratory Report LA-8939-MS (ISPO-142) (1981).